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Implications of Palm-based Biodiesel Blend Mandate on the Biodiesel Industry Growth in Malaysia: Evidence from Causal Loop Diagram

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Abstract: The government's recent announcement to increase blend mandate of B10 for transportation sector and B7 for industrial sector is being welcomed by experts as a huge turning point for Malaysia palm-based biodiesel industry. However, concerns remain on the viability of the industry, especially during low crude oil price period. The main aim of this paper is to assess the impact of various blend mandates on Malaysia's biodiesel industry based on cost-profit, environmental, and wide economic perspectives. This research employs the causal loop diagram of system dynamics method which explains how things change through time and how actions and reactions cause and influence each other. The findings indicate the government's effort is rational and has a positive impact on the environment and economy but a negative impact from the cost-profit perspective. The study results allow policy makers such as MPOB to understand and to predict how various blend mandate might affect not only the biodiesel industry in the long term but also the cost-profit, environmental and other economic variables.

Keywords: Palm-based biodiesel, conceptual model, system dynamics, causal loop diagram
JEL classification: E3, Q1, Q4

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1. Introduction

The world is turning to renewable energy sources to reduce dependency on fossil fuel due to environmental and climate change concerns related to the latter (Cottrell, François, & Kai, 2015; Pimentel, Herz, Glickstein, Zimmerman, Allen, Becker, Evans, Hussain, Sarsfeld, Grosfeld, Seidel,

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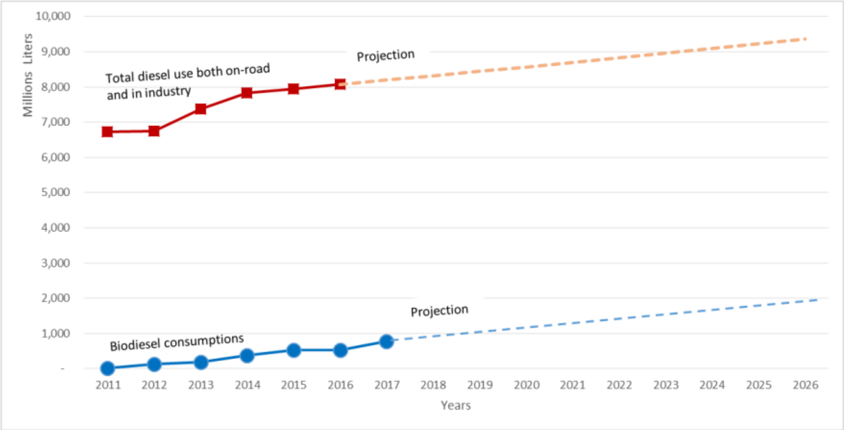
2002). Even though plunging crude oil prices mean less pressure to source alternative energy, has environmental concerns are leading the search for renewable energy. In doing so, government policy plays an important role in facilitating the adoption of renewable energy. One of the important sources of renewable energy is biofuel. Biofuel is produced from vegetable oil and commonly blended with fossil fuel to be used in transportation and industrial sector. Some sectors have even used 100% percent biofuel without blending it (e.g. B100 biodiesel) with no reported engine issues. These has given hope to the global community to reduce their dependability on fossil fuel.

Palm-based biodiesel is produced by processing palm oil into a substance called Palm Methyl Esther (PME). PME is a pure form of biodiesel which is also called B100. Currently a commercial use, biodiesel is blended with petrol diesel under the biodiesel mandate programme. The mandate programme is termed as B*x*, where '*x*' represents a number which defines the percentage of biodiesel blending with petrol diesel. For instance, a B5 mandate program means the blending of 5 percent biodiesel with 95 percent of petrol diesel. Since it is derived from renewable sources, biodiesel has a huge advantage over petrol diesel because it does not contribute to the increase of carbon dioxide (CO_2) and emit greenhouse gasses into the atmosphere. This is due to the oxygenated nature of palm oil and the lower amount of carbon in palm biodiesel blends (Aziz et al., 2006). According to experts, biodiesel emits approximately 40% to 50% less CO_2 as compared with petrol diesel in vehicle engine and electrical generator respectively (Pehnelt & Vietze, 2013). Hypothetically, the implementation of B100 which is referred to 100% of biodiesel will have substantial positive impact on the environment. In terms of engine technicality, biodiesel actually is more lubricating compared with petrol diesel as it extends the engine life. Additionaly, it is better than sulphur as lubricating agent as the latter emits sulphur oxide when burned (Nagi et al., 2008).

In Malaysia, government has launched biodiesel blend mandate to stimulate the growth of biodiesel industry. However, experts are questioning the government's commitment and their concerns relate to influence of crude palm oil price (CPO) when biodiesel supply and demand enter the dynamic equation. When CPO price increases sharply due to vibrant biodiesel demand, this will negatively affect downstream sector that uses CPO as their main input, particularly food manufacturers. Ultimately, the production cost will be borne by consumers. Another main concern is the cost that has to be borne by the government in order to retain biodiesel price competitiveness. This has been a major issue due to the low global crude oil price (Personal Communication, month, date, 2016)[1]

Despite this, the government recently announced the launching of new biodiesel mandate for transport sector from B7 to B10 and the use of B7 in industrial sector. Their implementation are expected to contribute to the consumption of around 750,000 tonnes of CPO annually as feedstock (Adnan, 2016). Biodiesel consumption is also expected to increase following future trend projection of petrol diesel consumption on-road and industrial sector as shown in Figure 1. Assuming the government will continue the B10 programme until 2026, the consumption of biodiesel for blending purpose is expected to achieve 2 billion litres in 10 years. Further, the future biodiesel consumption may be higher than this given that there is likely increase of biodiesel mandates in the future (with B15 targeted in 2020 under the Malaysia 11thplan).

Figure 1: Malaysia's Biodiesel and Diesel Consumptions by Vehicle Users and the Industrial Sector



(Source: USDA, 2016; Author Projetion)

This study attempts to undertake a comprehensive preliminary analysis of the government's policy rationale on the biodiesel industry using a conceptual model known as causal loop diagram (CLD) of system dynamics (SD). The SD approach allows for holistic causal and impact analysis of biodiesel blend mandate on Malaysia's biodiesel industry. Furthermore, CLD is one of the mapping tool in SD that can be used for future development of stock flow diagram. Stock flow diagram is a technique that can provide a basis for simulating the behaviour of palm oil

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[1] A personal interview with top rank official from the body that represents all biodiesel producer interests in Malaysia.

[2] B5 refers to 5% biodiesel with 95% petrol diesel; B7 refers to 7% biodiesel with 93% petrol diesel and B10 refers to 10% biodiesel with 90% petrol diesel.

mandate that allow us to test the effect of changes in policies governing the biodiesel industry (Sterman, 2000). The study results are crucial as a preliminary effort in improving the prospects of Malaysia's biodiesel industry.

2. Overview of Malaysia Biodiesel Industry

As part of the government campaign to reduce its dependability on fossil fuel, Malaysia has launched the National Biofuel Policy (NBP) in 2006 (MPIC, 2006) to promote biodiesel usage domestically in all sectors. Further, Malaysia has launched the pilot B5 mandate programme in Putrajaya in 2011. This was later implemented in Malacca on July 11th, Negeri Sembilan on August 1st, Kuala Lumpur on September 1st, and Selangor on October 1st of the same year. The B5 mandate programme requires the blending of five percent biodiesel with 95% petrol diesel targeted at the transport sector. In 2014, the government increased the blend mandate from B5 to B7 for this while in 2016 the government announced B10 mandate programme for transport sector and B7 for industrial sector. The implementation of B10 is deemed by experts to be a huge turning point for Malaysia's biodiesel industry and puts Malaysia at par with other biofuel producing countries such as US, Brazil, Indonesia Argentina and Colombia (Adnan, 2016). This is especially due to the still underdeveloped biodiesel industry compared with Malaysia's rival Indonesia which is already at B20. The reason Malaysia lags behind is the unsuccessful attempt of expanding biodiesel market domestically and internationally due to unfavourable market conditions (Mohammadi et al., 2016), namely high CPO prices and low crude oil prices, which together delayed the implementation of mandate programme (Adnan, 2016).

Malaysia's biodiesel mandate programme was launched for the purpose of stimulating domestic palm oil-based biodiesel (POB) demand. It was also meant to act as a CPO price stabilising mechanism (Anonymous Biodiesel Producer, 2016). This is supported by finding from previous studies that found significant influence on CPO prices with the increase in POB demand (Ramli et al., 2007; Rahman et al. 2011; Shri-Dewi et al., 2011; Shri-Dewi et al., 2014). Furthermore, with high CPO stock reported each year, vibrant POB industry may help in utilising the excess stock. With the new implementation of B10 for transportation sector and B7 for industrial sector, the industry expects the combine POB consumption of approximately 750,000 tonnes of CPO per annum (Adnan, 2016).

Despite apparent government commitment in promoting biodiesel industry, experts have raised several concerns on the economic viability of the industry even from the start of its launching (The Star, 2007). One of the important issues is regarding the high and uncertain prices of CPO (the main feedstock of biodiesel production). In the period of high CPO price, the production cost of biodiesel will increase subsequently resulting in deterioration of its price competitiveness compared with petrol diesel price. Since biodiesel is a mandate-driven industry, government has to play its role by absorbing the price difference to retain biodiesel price competitiveness. This situation is exacerbated when global crude oil price is comparatively low like what happened in 2016 which raises the question whether it is an appropriate move for government to increase the blend mandate to B10. Theoretically, high blend mandates will increase biodiesel demand to increase CPO prices. This in return may negatively impact the downstream sectors like food manufacturers that use CPO and processed palm oil (PPO) as its raw material. For this reason, current general perception on biodiesel industry can be concluded as not favourable (Anonymous Biodiesel Producer, 2016).

Hence, the use of appropriate method will help in evaluating the rationality of government commitment to uphold the biodiesel industry, particularly in the current unfavourable economic period. Review of some of previous studies on Malaysia biodiesel industry is presented in the next section.

3. Literature Review

Most of the previous studies on Malaysia biodiesel industry employed econometric time series analysis. One of the earliest study Ramli et al. (2007) included biodiesel demand in the price equations. The autoregressive integrated moving average (ARIMA) method was used to estimate palm oil price from July 2006 to end of 2007. The findings showed that the palm oil price is forecasted to remain high averaging RM3500/ton in 2008. Shri Dewi et al. (2011a), analysed the link between biodiesel demand and Malaysian palm oil market by using annual data for the period 1976 to 2008. The econometrics analysis used in this study included the role of stationarity and cointegration as a prerequisite test before using the simultaneous equation estimation procedure. This study was extended in the same year by focusing on the link between biodiesel demand, petroleum prices and palm oil market (Shri Dewi et al., 2011b). Further, a study in 2014 by Shri Dewi et al. (2014) investigated the impact of B5 mandate implementation on Malaysian palm oil market using Two Stages Least Squares (2SLS) method. These studies have shown a consistent finding on the significant impact of biodiesel industry on CPO prices. Based on the reviews, it can be concluded that those studies using econometrics method which normally rely on heavy data usage showed an increase in CPO prices due to the increase in POB. However, some shortcomings have been highlighted when using the observation-based modelling method like econometrics method which include historical data to forecast future trend, and the limitation in capturing the feedback processes which are prevalent in a complex palm oil market model (Olaya, 2016). Due to the complexity of palm oil market modelling, there is a need to move the paradigm of modelling using the operation-based method as opposed to the observation-based modelling method. Therefore, the use of system dynamics (SD) in this research will fill the gap of previous methods (Ramli et al., 2007; Shri Dewi et al. 2011a and 2011b; Shri Dewi et al. 2014). The SD is a simulation approach based on operation-based method that analyses economic behaviour and underlying feedback process in a palm oil system. The SD models a system following the operations involve in the system (in a string of processes) and incorporates the actual factor that influences the operation rather than numerical percentage of probability only (Olaya, 2016). The following reviews the most recent studies which adopt SD method in analysing Malaysia's biodiesel industry.

Mohammadi et al. (2016) examined the impact of palm-based biodiesel on CPO production in Malaysia. The authors used SD to simulate scenario of B10 and B15 blend mandates. The findings indicate an increase in fresh fruit bunch (FFB) yield and CPO production in Malaysia when additional demand is created with the implementation of higher blending mandate. The study on the other hand, did not conclude the practicability of increasing blend mandate. This is important to verify government persistence in developing biodiesel industry relevancy, particularly in the current period of low crude oil price. In order to test the impact of various blend mandates, Shri-Dewi et al. (2015) employed SD to investigate suitable blend mandates for biodiesel industry in Malaysia. The study simulated the scenario of B5, B7 and B10 implementation and analysed their impact on Malaysia palm oil industry. The findings showed that increasing blend mandate is not economically feasible because it will increase the need for biodiesel subsidies by government to ensure the biodiesel price remains competitive compared with petrol diesel. However technically, the scope of the model was limited to the perspective of cost-profit of biodiesel production only. Hence, the model should expand its scope by considering the impact of the environment or wide-economic perspective that will allow a multi-perspective analysis to avoid bias conclusion on Malaysia biodiesel industry.

Hence, this study adopts the SD method in an attempt to understand the dynamics of Malaysia's biodiesel industry. Unlike the aforementioned previous studies, additional variables have been incorporated here, namely cost-profit, environmental and economic situations so that multi-perspective analysis can be executed. The development of SD model involves several stages and this study on the other hand focuses on the initial stage of SD model development called conceptualisation stage. A conceptual model is built to describe the relationship between main variables and greatly facilitate the development of SD model. In this study, the biodiesel industry is analysed using a conceptual model to obtain initial insights into the dynamics of the biodiesel industry.

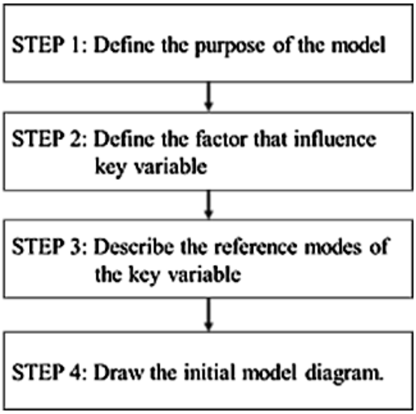
4. Methodology and Framework

4.1 Conceptual Stage in System Dynamics

The SD has its roots in industrial dynamics (Forrester, 1961). The concept evolved into SD and has been widely used in operation research field to study agriculture (Shri Dewi et al., 2015), human diet management (Abidin et al., 2014), and healthcare (Halim et al., 2015). The SD's main attributes include its intensification on feedback process when modelling a system. It also provides a platform for experimenting the impact of various scenarios and possible policy interventions in a system.

In the conceptual stage, dynamic hypothesis is formulated before developing SD model. Dynamic hypothesis provides an explanation of the underlying feedback process in the system, thus, guiding the modelling efforts by focusing the modeler on certain structures (Sterman, 2000). The step for building dynamic hypothesis can be referred to Albin (1997). As shown in Figure 2, there are four essential steps including defining model purpose, defining the factors that influence key variables, describing the reference mode, and constructing the initial model diagram.

Figure 2: Steps in Formulating Dynamic Hypothesis



In the final step of building dynamic hypothesis, an initial model diagram will be produced. This initial model diagram acts as a conceptual model. In the standard SD modeling practice, conceptual model is usually built using CLD. Theoretically, CLD is used to capture the qualitative element of the studied system. It is very helpful in the early phases of model building, especially in capturing the mental model of the problem in non-technical fashion (Sterman, 2000). The CLD capture two types of feedbacks process in the studied system: positive and negative feedback. Positive feedback acts as self-reinforcing force which amplifies effect brought by changes of variables in a loop. On the other hand, negative feedback poses a balancing loop where changes in a variable leads to a counteracting change of the total output in the loop (Morecroft, 2007). Positive and negative feedback are sometimes marked with 'R' and 'B' denoting 'reinforcing' and 'balancing' respectively.

Albeit its usefulness, CLD only acts as tool for preliminary analysis of studied system and can never be taken as complete imitation of real system. The limitation of CLD includes non-distinguishable stocks and flows and lacking in detail of feedback loops of the system (Sterman, 2000). The final SD model often includes the quantifying process of the inter relationship between variables and a stock and flow diagram (SFD) before a full technical analysis. In this study, a comprehensive preliminary analysis of Malaysia biodiesel industry is done using CLD. A full model in a form of SFD will be developed as a continuum from this study for future works.

4.2 Conceptual Model of the Malaysia Biodiesel Industry

The conceptual model related to Malaysian biodiesel industry is based on the dynamic hypothesis development proposed by Albin (1997). It involves establishing the purpose of the model development, defining the key variables, constructing reference mode and developing causal loop diagram. The following subsections details the steps.

4.2.1 Model development purpose

The purpose of the model is to study the effect of increasing biodiesel blend mandate on Malaysia palm oil industry and its biodiesel sector.

4.2.2 Key variables of the model

The key variables in biodiesel industry are identified through literature review supported by primary and secondary data obtained from interview sessions with selected players in the industry. These include producers and governing body which is directly involved in designing policies for the biodiesel industry. Secondary data is obtained literature review and Malaysia palm oil database available for public access (see Malaysian Palm

Oil Board (MPOB) website (MPOB, 2016)). Table 1 summarises the data type and its sources.

Table 1: Type of data and its source

Data type	Description	Source	Year
Primary data	Overview of the past and current situation of Malaysian palm oil industry.	• Meeting with industry players	2015
Secondary data	Historical time series and latest data on palm oil market (e.g., production, prices, export, and consumption)	• MPOB website • Newsletter from MPOB • Annual report from MPOB	2000-2015

There are several key variables identified in the biodiesel industry. Table 2 lists the key variables classified as exogenous or endogenous variables. The list is an initial compilation of important variables to for the SD model.

Table 2: List of key variables included in the model

Type	Variables	Description
Endogenous	Biodiesel supply	Biodiesel supply represents production and stock of biodiesel.
	Biodiesel demand	Domestic and export demand.
	CPO supply	The feedstock for biodiesel is CPO so it is important to include CPO supply which includes CPO production, import and stock.
	CPO demand	Apart from biodiesel feedstock, CPO is mainly used to process PPO which is the main ingredient in food and non-food industry.
	CPO prices	The ratio between CPO supply and demand determines CPO prices. With an increase in CPO demand to cater biodiesel sector, CPO prices will be significantly affected.
	Overall revenue from palm oil sector	Palm oil and its products is one of the major contributors to Malaysia Gross National Income (GNI). The fluctuation of CPO prices has a significant impact on the nation's income and revenue.
	Livelihood quality of smallholder	Compared with major oil palm plantation estates, oil palm smallholder is the most affected by CPO prices.

Table 2: (Continued)

Type	Variables	Description
Exogenous	Biodiesel mandate	The main policy in biodiesel industry is biodiesel blend mandate.
	Petrol diesel prices	Petro diesel price influences the competitiveness of biodiesel prices.

The list starts with biodiesel supply consisting of production and stock of biodiesel. Biodiesel (known as palm methyl esther or PME) is produced from the CPO or PPO by selected palm oil company. The production made up the stock of biodiesel is later supplied to petroleum company for blending process. As biodiesel is a mandated industry, biodiesel demand stems from the enforced biodiesel mandate.

The CPO is the feedstock for biodiesel production so it is critical to incorporate it into supply, demand and prices to investigate how the changes in biodiesel demand variates these variables. The CPO supply includes CPO production, stock and import. The CPO production refers to extraction of oil from fresh fruit bunches (FFB). The extracted oil is accumulated as a stock which is also contributed by the import of CPO. CPO demand, from both biodiesel and non-biodiesel sector, acts as the output which depletes the stock. . The ratio of CPO supply and demand determines its prices. The price is crucial as the determinants of biodiesel prices.

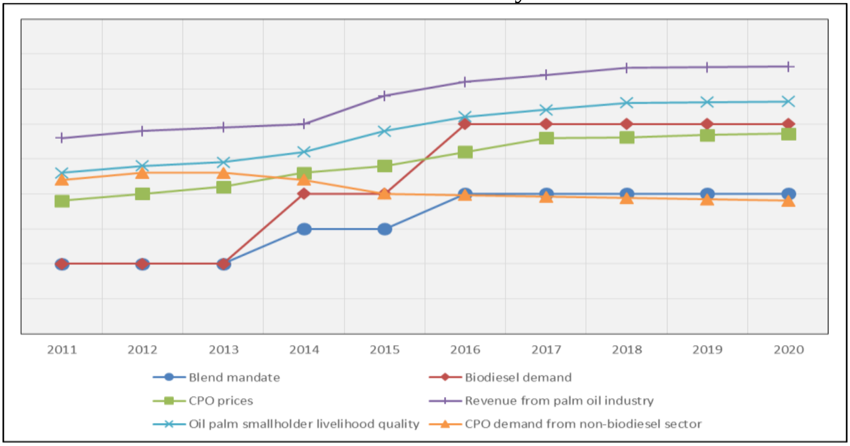
The variable overall revenue from palm oil sector termed as the collective revenue gained from palm oil sectors, determines the fluctuation in CPO prices. This either improves or impacts negatively on the livelihood of oil palm plantation smallholders. Compared with the big plantation companies, smallholders are the most affected when the CPO price is low. Thus, from a socio-economic perspective, including this variable can be an important benchmark on the impact of CPO price on palm oil industry.

The exogenous variable, biodiesel mandate, is the policy lever that influences biodiesel demand in Malaysia. Finally, petrol diesel price is used as an exogenous variable that plays an important role (besides CPO prices) in determining the price of biodiesel. Petrol diesel price also acts as reference that sets the competitiveness of biodiesel price in the market. In the later stage, more variables may be added to understand the model and to depict the real system with accuracy.

4.2.3 The hypothesised reference mode

For comparison, the reference mode is established from historical data or hypothesised patttern built by plotting the behaviour of key variables in a system over time. Reference mode is essential both as a guide and a test throughout the model building process (Albin, 1997). In this study, a hypothesised pattern was used as reference that was plotted based on the observed behaviour from historical data as well as the information gathered from industry players. One of the important policy in biodiesel industry is biodiesel blend mandate. Based on the reviewed literature and interview with industry players, the increase of blend mandate is hypothesised to increase biodiesel demand, CPO prices, overall revenue from palm oil industry and the livelihood of oil palm smallholders. On the other hand, with the increase in CPO prices the demand for it will increase in diminishing rate until the CPO prices reach the highest tolerable level and eventually tumble demand. However, this process involves time,particularly in the case where price of commodity is based on future price contract. In terms of the model time horizon, the period 2000 until 2030 is chosen. The time horizon is assumed sufficient in depicting the pre- and post-implementation of biodiesel blend mandate in 2011. Figure 3 shows the hypothesised mental model used as references mode in this study.

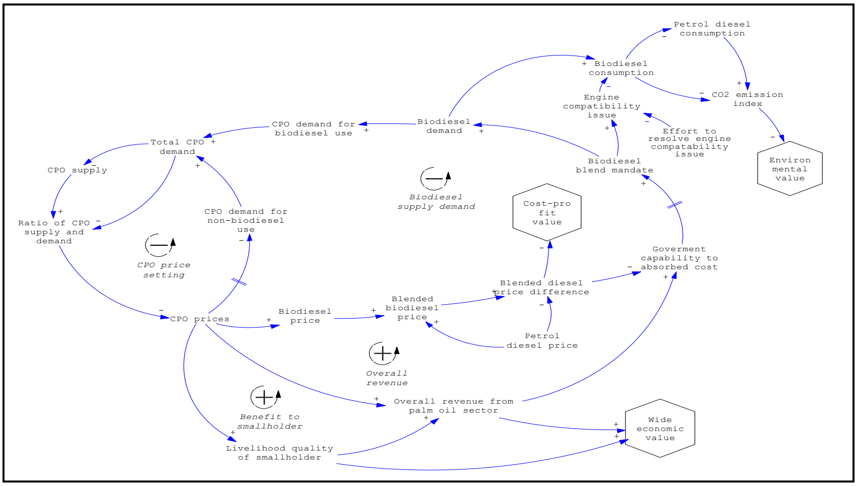
Figure 3: Hypothesised mental model of key variables in Malaysian biodiesel industry



4.2.4 Causal loop diagram for biodiesel industry

CLD is shown as a model diagram initially to determine the basic mechanism of Malaysia biodiesel industry. Figure 4 shows the CLD for this study with two positive and negative feedback loops. The impact of biodiesel industry will be measured based on three values, namely environmental, cost-profit, and wide economic variables. Note that these variables are shown in a hexagon box.

Figure 4: Causal loop diagram of Malaysian biodiesel industry



The first negative loop is CPO price setting loop. CPO supply and demand makes up a ratio of CPO supply and demand. This ratio determines CPO prices. When CPO demand exceeds its supply, it price will increase and vice-versa. High CPO prices discourage the purchase of CPO for non-biodiesel production such as food and non-food industry. However, the CPO price effect on demand may involve some delay because the commodity trade normally depends on future contract prices. High CPO price eventually will lower CPO demand for non-biodiesel use and decrease total CPO demand. Low CPO demand increases the ratio as CPO demand exceeds its supply and increase CPO prices again.

The second negative loop is biodiesel supply demand loop. With the addition of biodiesel supply demand loop, it will further help in increasing CPO price and act as stabilising mechanism. When CPO price is low due to excess in CPO supply, additional CPO demand from the biodiesel sector helps in boosting CPO prices. CPO price unfortunately contributes to the increase in biodiesel price due to the fact that major portion of biodiesel production cost is its feedstock price (Yahaya et al., 2006). The blended diesel price then is dictated based on biodiesel price and petrol diesel price using Automatic Price Mechanism (APM) under strict government supervision (Anonymous Biodiesel Producer, 2016). The biodiesel industry in Malaysia is currently mandate-driven. Thus, the difference in blended biodiesel price will be absorbed by the government to retain its competitiveness compared withpetrol diesel price. On that account, this raises the question regarding how far the government will continue to absorb the price difference. The higher the difference between blended diesel price and petrol diesel price, the lower its cost-profit value.

The government capability to absorb price difference will influence, albeit after some delay, the decision to increase blend mandate. In other words, it may take some time before new blend mandate is announced because the increase of the latter will stimulate greater demand for biodiesel, disrupting CPO supply-demand ratio and ultimately increases biodiesel price. Wider price gap requires government to absorb more cost to ensure the competitiveness of blended diesel price.

The increase of blend mandate is also a solicit issue such as engine compatibility. This was raised during the recent launch of B10. Automakers raise concerns of possible engine damage with the usage of B10 diesel (The Malaysian Reserve, 2016). It will take some time to resolve the engine compatibility issues before B10 can be fully accepted by automaker. In the same loop, the increase in biodiesel consumption offsets the usage of petrol diesel, particularly in the transportation sector. The use of biodiesel reportedly emit 40% - 50% percent less CO_2 compared with petrol diesel (Pehnelt & Vietze, 2013). Hence, higher biodiesel consumption will result in higher environmental value.

The final loop is the overall revenue loop and benefit to smallholders loop. Higher CPO prices contributes to national revenue. In a simple term, every increment of RM100 in CPO price per tonne contribute to RM2 billions of national revenue from palm oil industry (Adnan, 2016). More revenue will strengthen the government's capability to absorb the cost difference between blended diesel price and petrol diesel price. Subsequently, biodiesel will continue to grow vigorously under this loop as long as CPO price keeps increasing. Nevertheless, the price setting loop will balance out the outcome and keep CPO prices from becoming extremely high. Stable CPO price keeps all affiliate industry, such as food and non-food industry as well as biodiesel sector from severe consequences. Moreover, stable CPO price will also ensure the livelihood quality of oil palm smallholder at satisfying level. Oil palm smallholder is the most affected party during periods of low CPO due to their small scale economic activity compared with estate owners (The Malaysian Reserve, 2016). Both overall revenue from palm oil industry and livelihood quality of smallholder variables determine the wide economic value of biodiesel industry in this study.

5. Findings: Scenario Evaluation

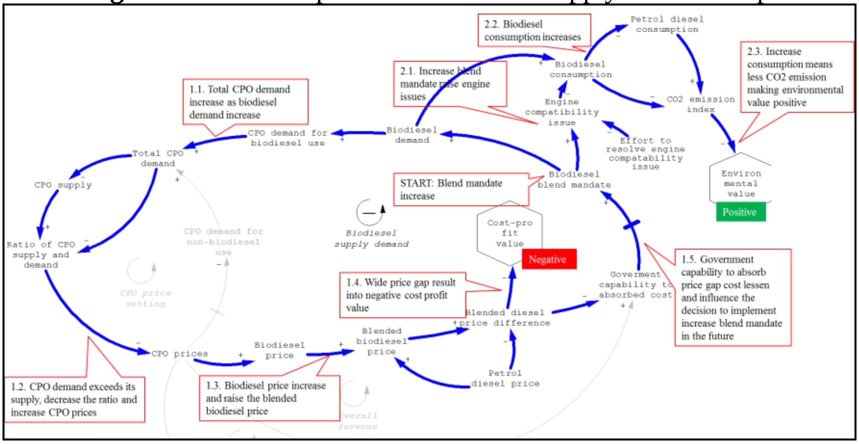
Although CLD has limitation in its function to imitate the real system for full analysis, it is always provisional in capturing the important feedback process in a complex system (Sterman, 2000). Thus, initial analysis based on CLD can be done for brief understanding of the basic mechanism and the component's impact on the system behaviour. This section begins with an analysis ofof current economic situation in Malaysia which is used as a conceptual model for analysis. Each loop in the conceptual model is elaborated.

In 2016, global crude oil price was at its lowest in the history at approximately USD47 per barrel (NASDAQ, 2016). Further, in the same year, the government announced the launching of B10 for transportation sector and B7 for industrial sector which triggered concerns whether it was the right move by government given that average CPO price is currently high averagingRM2700 per tonne, making biodiesel price less competitive compared with petrol diesel (MPOB, 2016).

The implementation of new blend mandate stimulate CPO demand for biodiesel. In biodiesel supply demand loop, the ratio of CPO supply over demand will drop and further boost CPO prices. Increase CPO prices means extra cost for biodiesel production thus increasing biodiesel prices and widening the price gap with petrol diesel. The current low petrol diesel price means biodiesel price is more competitive. This means the government has to bear higher cost to sustain the production of biodiesel. Cost-profit value thus, shows a negative value. Nevertheless, increased biodiesel mandate triggers greater demand for biodiesel which in turn increases its consumption. High biodiesel consumption offsets petrol diesel consumption. Industry experts expect the implementation of B10 and B7 in transportation and industrial sector respectively will consume up to approximately 750,000 tonne of biodiesel. That is equivalent to an offset of 750,000 tonne petrol diesel consumption and about 40 to 50 percent or 375,000 tonne equivalent less CO_2 emission. Its environmental impact is significant, thus, environmental value has a positive value. Figure 5 shows the feedback process in biodiesel supply demand loop.

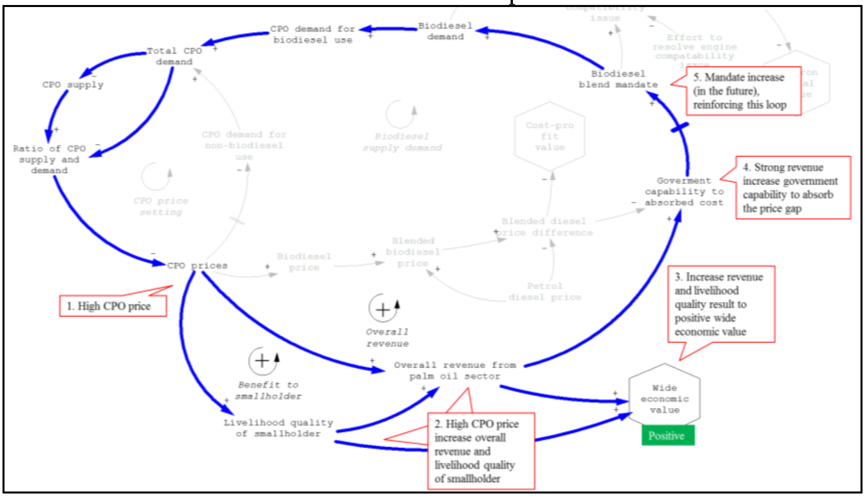
Therefore, scenario evaluation shows that environmental and economic values have positive values while cost-profit value is negative. Based on this result, it is proven government commitment in developing biodiesel is rational, even though the current economic condition is unfavourable. Malaysia's closest biodiesel rival is Indonesia. Being the two biggest palm oil producers in the world, Malaysia and Indonesia have the potential to capture 20% of the world's biofuel market (Arshad, 2008). The result conforms to these facts, as long as the price of CPO remains attractive compared with that of crude oil. Further, the increase of efficiency of CPO production through labour and technology may help the industry to cater to increasing demand from biodiesel sector in the future as suggested by Mohammadi et al., (2016).

Figure 5: Feedback process in biodiesel supply demand loop



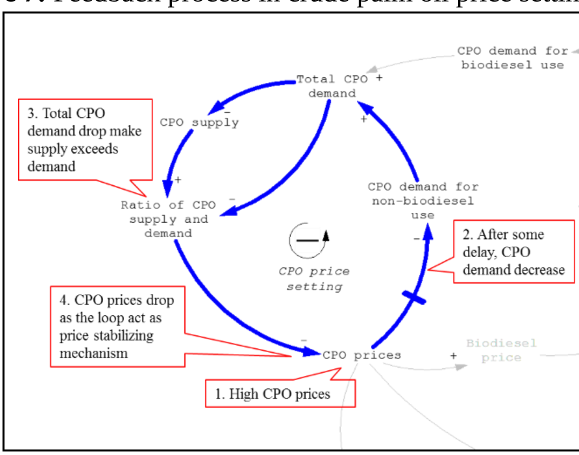
With high CPO prices, the overall revenue from palm oil sector increases and contributes to the capability of government to absorb cost differences between blended diesel and petrol diesel prices. Simultaneously, high CPO prices benefit the livelihood of oil palm smallholders which contributes to the increase of overall revenue in the palm oil sector. This is because with good income, there will be less allocation to help smallholders in terms of their daily expenses as well as plantation activities. Moreover, good income stimulates domestic economic activities in non-direct fashion because it increases the purchasing power of oil palm smallholder. Hence, wide economic variable shows a positive value. The feedback process in overall revenue loop and benefit to smallholder loop is shown in Figure 6.

Figure 6: Feedback process in overall revenue loop and benefit to smallholder loop



In the long term, high CPO prices has negative impact on non-biodiesel industry and after some delay the demand will slow due to capacity planning to accommodate high raw material prices. Slow demand increase CPO supply vis-à-vis its demand and eventually return CPO price back to its equilibrium. Note that the process involves delays because CPO price purchase is normally based on future contract prices, where short term CPO price fluctuation has little impact on production. In this scenario, price setting loop act as price stabilising mechanism due to perturbation from biodiesel supply-demand loop. Figure 7 shows the feedback process in price setting loop.

Figure 7: Feedback process in crude palm oil price setting loop



6. Conclusion

In this study, we assess the impact of various blend mandates on Malaysian biodiesel industry on cost-profit, environmental, and economic variables. Analysis using conceptual model based on current economic situation produced positive impact on the environmental and economic variable but negative impact on the cost-profit variables. These suggest the rationale behind government persistence in promoting and developing biodiesel industry despite unfavourable economic conditions.

Another important findings from the analysis is the palm oil industry has become effective in terms of price stabilising mechanism with the addition of biodiesel supply demand loop. In the period of low CPO price, biodiesel can help in boosting CPO price by utilising excess CPO stock and supress CPO supply. Biodiesel production is not significantly affected by high CPO prices because it is mandate-driven industry. However, extremely high CPO prices may negatively affect CPO demand for the non-biodiesel sector in the long term. When this happens, negative price setting loop, after some delay, will act as a stabiliser and return CPO price to the optimal level. In other words, the presence of two negative loops complement each other as CPO price stabilising mechanism. Stable CPO price boosts growth both for palm oil and palm-based biodiesel industry.

The use of conceptual model for analysis has produced comprehensive preliminary insight on Malaysia's biodiesel industry. However, the analysis is subject to technical limitation of CLD. Thorough analysis is plausible through the quantification of component relationships and addition of necessary details by developing SFD. In addition, counter-intuitive behaviour may also be revealed during the analysis of SFD. Next step will be the development of quantitative model in the form of SFD followed by various validation test of its structure and behaviour. SFD will permeate more thorough and technical analysis of Malaysia biodiesel industry.

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